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(54) Title: TRAFFIC MANAGEMENT IN A MOBILE COMMUNICATION NETWORK
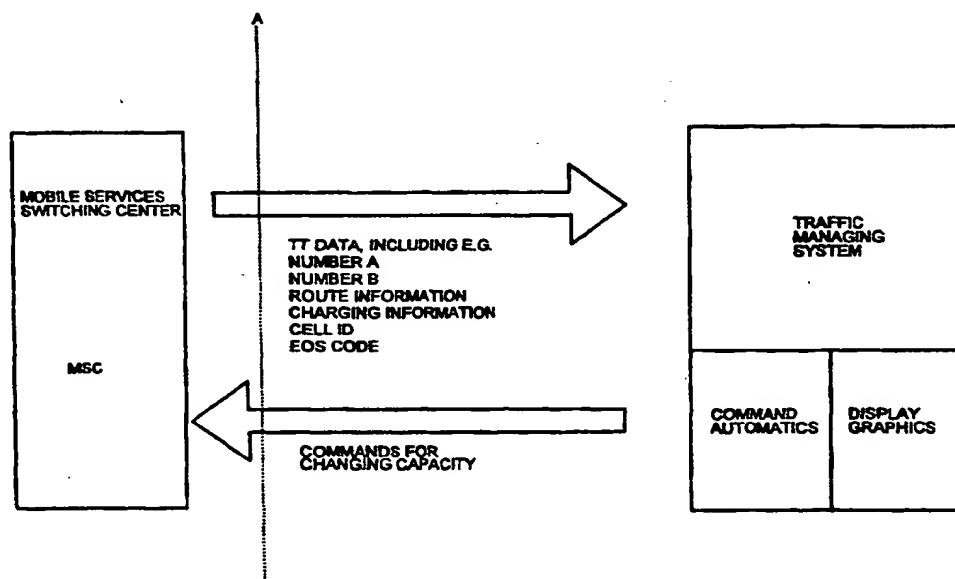
(57) Abstract

A traffic management system reads TT files obtained from Mobile Service Switching Centers, and processes information included in the records of the files, and on the basis of the information produces a hierarchical graphic representation on a map display. The highest level represents the operator's entire service area, and the lowest level a cell. On each level, traffic intensity is displayed with grades of colour, i.e. the more traffic the stronger the colour. The display is updated automatically as the MSC provides the TT data. The system monitors traffic load in the cells. If the traffic load in any one of the cells exceeds a preset level, the system automatically transmits a command to the MSC to change the logic size of the cell or add a TRX unit, if such is available.

Traffic management in a mobile communication network

The present invention relates to a traffic
management system for a cellular mobile communication
5   network in which a mobile services switching center
generates a TT (Toll Ticket) record after every call. The
record at least contains information on whether the call
succeeded or failed, as well as a cell identifier
indicating which cell the call is associated with. TT
10   records generated during a specific time interval are
combined into a TT file for further processing.

In the following, the structure of a mobile
communication network will be described with a prior art
GSM mobile communication network of Figure 1 as an
15   example. Communication between a Mobile Station (MS)
within a cell and the network takes place on the radio
path via a Base Transceiver Station (BTS). The base
transceiver stations are coupled to a Base Station
Controller (BSC), which usually controls several base
20   stations. The location of the MS is known with an accuracy
of a so-called Location Area (LA), constituted by a few
cells. The mobile station may roam within the location
area without updating its location data. Several base
station controllers are coupled to a Mobile Services
25   Switching Center (MSC), which carries out the principal
switching functions of the mobile communication network.
The entirety of cells under control of the MSC is referred
to as an MSC area; all calls originating from this area
and terminating therein are forwarded via this MSC. In
30   addition, it connects the mobile communication network to
external networks and via a so-called gateway MSC to
mobile communication networks of other operators.

A mobile communication network also comprises
different kinds of databases. A Home Location Register
35   (HLR) permanently stores a subscriber's data regardless of

his current location. Subscriber data obtained from the HLR are stored in a Visitor Location Register (VLR) during the subscriber's visit to the VLR area.

In order for the operator to be able to charge the subscriber for calls and services, the traffic management part of the network has a mechanism by means of which a sufficient amount of data will be stored for every service to be charged. The most significant traffic-related charging basis is constituted by calls. In the MSC, a so-called Toll Ticket record is produced for each call as soon as it has ended, containing all the necessary information to calculate the charges for the call. The contents of the record depend on the switching center technique being employed and the operator requirements. The gateway MSC exchanges messages with the HLR in accordance with a MAP/C protocol, and the prior art message exchanging enables including at least the following data in the TT record fields:

(a) at first, identifiers, i.e. the subscriber's IMS number and the identifier of the MSC that generated the record,

(b) secondly, the type of the call, i.e. whether the call is a mobile originating call or a mobile terminating call forwarded by the MSC (this means that the TT record also contains routing information from the switching center to the mobile station),

(c) if the switching center is a gateway MSC, the record contains routing information GMSC-MS,

(d) mobile terminating call re-routing information GMSC-MSC, if the MSC is in another network,

(e) call status, i.e. information on whether the call succeeded or failed. The data of failed calls are only utilized for statistical purposes, and therefore the manufacturer of the switching center does not always include it in the TT information,

(f) date, call begin moment, duration and nature. The last one indicates whether speech, data, a short message etc is in question,

(g) the number of the calling party (in mobile terminating calls) or the number of the called party (in mobile originating calls),

(h) charging, collected by the target operator from the subscriber's operator in cases of roaming,

(i) cell information (Cell ID), indicating the cell of the incoming/outgoing call.

The fields listed above are exemplary only, and the supplier of the switching center may add other fields according to the operator's requirements. The TT records are stored in an I/O apparatus of the MSC as a file which is at predetermined intervals transferred to a charging system for further processing. Typically, the transfer is carried out at intervals of 5 to 15 minutes, which therefore represents the real time delay for the data.

The chart of Figure 2 illustrates the use of the aforementioned parameters in a TT record. The fields of the record include the numbers of subscribers a and b, date, time of call begin and end, route, cell ID, call charging pulses and an EOS field. The EOS (End of Selection) is a clear code defining the reason why the call did not go through. There may be in use as many as 1000 different codes. Code 0 means that a call succeeded, and a code other than 0 indicates not only a failed call but a reason for it as well.

As the mobile communication network expands and call intensity varies, the network must continuously be modified. Increase in capacity can be provided by adding new TRX units in the cell, and by adding new nodes (MSCs and BSCs) and new cells whereby the transmission routes also change. To carry out the changes, and for operation, maintenance and managing functions the network produces,

from several locations, different kind of information; the BSC, for example, collects information from the cells it controls, whereby information on traffic intensity is obtained as a function of time. Information obtained from 5 various sources has to be gathered and processed in a centralized manner. In this respect, a mobile communication network does not differ from other telecommunication networks.

In present-day mobile communication networks, a 10 drawback of traffic management concerns poor real time representativeness. Information on peaks is only available a long time afterwards. Although the information on changes in traffic intensity is available, this is only after a long delay and in an unillustrative numerical 15 form. As a result, traffic capacity in some cells may run out, because dynamic allocation of traffic capacity in real time, or practically in real time, is not possible.

An object of the present invention is a system which makes traffic management easier by providing a 20 visually illustrative representation of traffic intensity and changes therein in practically real time. The system should be possible to couple to an MSC of any manufacturer, without need to change its internal functions.

25 This object is achieved with a system set forth in claim 1.

The management system is realized so that the TT file which is obtained from the MSCs of the mobile communication network and which contains TT records is 30 read and transferred to be incorporated into a database of the traffic management system. Traffic management software processes information obtained from the records, counts the number of calls carried out in the cells, and produces a hierarchical graphic representation of the information 35 on a map display. The term "hierarchical" here means that

the highest level is the entire geographical area, with
possibly several MSCs, under control of one operator. The
subsequent level may be an area of one MSC, and the
subsequent level may be a location area. The lowest level
5   is represented by one cell. Each level shows traffic
intensity with grades of colour, i.e. the more traffic is
present the stronger the colour. The display is
automatically updated as the MSC provides the TT data.

The management system also contains logic for
10   traffic load monitoring. This logic monitors the traffic
load on the network on different levels and in different
cells. If the traffic load in an area, within a cell or
cells, exceeds a predetermined level, the software
automatically transmits a command to the base station
15   controller in question to distribute traffic between the
overloaded cell and the neighbouring cells. This can be
done by changing the handover criteria by advancing
handovers at cell borders from an overloaded cell to a
cell with less traffic load, and correspondingly delaying
20   handover to an overloaded cell. The above can be referred
to as logically reducing the size of an overloaded cell.
If at the base station there is an additional so-called
floating TRX unit available, it can be coupled for use in
the overloaded cell and accordingly increase the cell
25   capacity.

The calculation results can be stored for
statistical purposes. The statistical data may constitute
for example congestion statistics, average duration of
calls per channel, degree of channel utilization, etc.
30   In the following, the invention will be described
in greater detail with reference to the attached drawings,
in which

Figure 1 illustrates the structure of the prior art
35   GSM mobile communication network,

Figure 2 illustrates fields of a TT record,

Figure 3 illustrates coupling of the traffic
management system to the mobile communication network,

Figure 4 illustrates a possible flow chart for
5   command automatics, and

Figure 5 shows network traffic load on a map
display.

Figure 3 shows a mobile communication network in
10   its entirety to the left of the broken line A. The mobile
communication network may have several MSCs, one being
illustrated in the figure. At precise intervals all
present-day MSCs generate for the operator a TT file
which, out of fields of Figure 2, at least contains all
15   other fields but the EOS field concerning possibly failed
channel requests. If the switching center nevertheless
generates such a field, but for a reason or another does
not include it in the TT record, the field will be
directed separately to the traffic management system of
20   the invention as well. If the switching center does not
generate such a field at all, relevant measures must be
taken in the center to generate the field.

The right-hand side of the interface A shows the
traffic management system of the invention. It is supplied
25   with the TT file obtained from the MSC: of the TT fields,
at least the number A, number B, route information,
charging data, i.e. begin and end time and pulses of the
call, cell ID and the congested calls data EOS are
utilized. The MSC generates a new TT file at predetermined
30   intervals, a typical sequence being 5 to 15 minutes.

The file received by the traffic management system
is transferred to be processed by the system. The system
distinguishes the records and processes them. Upon using
traffic intensity application, the cell ID fields will be
35   summed to their own database. As the TT record also

contains, for each call, the identifier of the cell from which the call was placed, or where it terminates, the sum of records having the same cell ID, calculated from the received TT file, represents the number of calls in this cell. If the MSC generates a new TT record for example every 10 minutes, the aforementioned sum denotes the number of calls in the cell during the past 10 minutes. In this manner, the number of calls can be established quickly for each cell of the network. The traffic intensity within a location area can easily be calculated by summing up the number of calls in the cells (under control of the same BSC) of the location area. Correspondingly, the traffic intensity for the MSC area will be obtained by summing up the number of calls in the location areas. Thus, traffic intensity can be calculated with an accuracy of a cell, location area, MSC area and the area of the entire mobile communication network.

On a display unit, traffic intensity is represented in a graphic form so that the map display shows the operator's entire area of operation, for example Finland. Because it is known where an MSC area, location area and a cell having a specific identifier are located on the map, a hierarchical representation of traffic intensity can easily be produced. On the highest level, traffic intensity can be displayed in the entire network area or by MSC area. By clicking the mouse at a desired MSC area, the resolution of the map display increases and the display shows traffic intensity by location area. By clicking the mouse once more, the map display shows the traffic intensity of the location area by cell, and finally the lowest level displays the intensity in a cell. On each level, it is possible to display alpha-numeric information concerning the level.

Traffic intensity may be displayed with grades of colour: on a cell level, a call is denoted by a pixel, for

example by a red colour. As a result, the higher the number of calls carried out in the cell the redder the cell appears. Correspondingly on the other levels, the grade of the red colour on the geographical area indicates

5   traffic intensity in the area. As the traffic management software always updates the display upon receiving a new TT file from the MSC, a clear picture is provided of changes in traffic intensity.

The results of the processing carried out after

10   reception of previous TT files are stored in a memory, which means that by displaying a desired number of calculation results in succession, the map display very clearly shows the changes in traffic intensity. For example, the map display may show how a specific red area

15   moves along roads according to vehicular intensity. The flow chart of the graphic illustration described above represents a direct sequence of the different functions: the data are read, values required are calculated and shown on the map display. Regardless of the high number of

20   different records, the calculation process is very fast. A person skilled in the art will realize that information obtained from the TT file can, in addition to calculating traffic intensity, be also used for various statistical purposes. These include for example congestion statistics,

25   average duration of calls per channel in a cell, degree of channel utilization, proportion of internal calls in the mobile communication network to all calls, proportion of calls coming in to the mobile communication network and calls originating from the mobile communication network to

30   all calls, etc.

The graphic map display of call traffic intensity is one of the features in the system according to the invention. Another characteristic feature is provided by the possibility to monitor, by means of the logic built in

35   the system, the traffic load in the radio network and to

automatically optimize the network capacity with commands generated by the system. If a cell is overloaded, or the upper limit of the capacity approaches, the system automatically transmits a command to the MSC e.g. to lower
5   the handover criteria by changing the logic size of the cell in question and/or to take in use in the cell an additional transceiver unit TRX if such is available.

Figure 4 shows how to implement the invention in a simple and fast manner. At first, the TT data required are
10   read (block 1). Congestion display and command automatics are carried out by means of EOS fields indicating failed and succeeded calls, and cell ID fields. At block 2, congestion percentage E is calculated by the formula:

15   E = (failed channel requests in a specific cell/all channel requests in the cell) * 100%.

For each cell, the congestion percentage is calculated every time the system receives a new TT file from the MSC.
20   When the congestion percentage E of a cell exceeds a preset value (block 3), the system automatically transmits a command to the MSC to adjust the logic size of the cell, i.e. to change the handover criteria of the cell (block 6) and to enlarge the neighbouring cells, i.e. to change
25   their handover criteria (block 7), or to add an additional TRX in the cell (block 5). The MSC commands the BSC controlling the cell to carry out the procedures required.

This system that processes large quantities of data can be implemented by using an efficient program code with
30   a PC-based apparatus; thus, a Unix work station, for example, will not be required unlike in prior art traffic management systems of fixed networks. The system can be coupled to an MSC of any manufacturer.

Finally, Figure 5 shows a graphic map display
35   illustration. The figure shows the highest level of an

operator's mobile communication network, the entire Finland. The dark areas indicate very high traffic intensity.

It should be understood that the description above and the figures related thereto are only intended to illustrate the present invention. It will be clear to a person skilled in the art that variations and modifications may be incorporated without departing from the scope and spirit of the present invention. The invention has been described in association with one mobile communication network, but it is obvious that in a mobile communication system comprising several MSCs the apparatus may be installed in one of them, and information from the other switching centers and commands to the switching centers can be transmitted by using an appropriate connection, such as an X.25 network.

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Claims

1. A call traffic management system for a cellular mobile communication network, in which a Mobile Services Switching Center generates, after each call, a TT record (Toll Ticket) at least containing information whether the call succeeded or failed and a cell identifier indicating which cell the call is associated with, and combines TT records produced over a specific time interval into a TT file, whereby at said intervals a new TT file will be generated for further processing,
c h a r a c t e r i z e d in that the management system

is connected to the MSC for reading the TT file and for transferring it to the management system as soon as the file has been produced, and for giving commands to the switching center,

contains counting means for counting the number of calls made in each cell of the network,

comprises a graphic user interface by means of which a hierarchical representation of the number of calls can be shown in which the highest level depicts the operator's entire mobile communication network, and the lowest level depicts a cell.

2. A management system as claimed in claim 1, c h a r a c t e r i z e d in that the management system comprises means for automatically giving a command concerning the capacity of the cell to the MSC when load in any cell exceeds a preset value.

3. A management system as claimed in claim 1, c h a r a c t e r i z e d in that the counting means distinguish a cell identifier field in every record of the TT file, and calculate for each cell the sum of cell identifiers, and that the sum represents the number of calls carried out in the cell.

4. A management system as claimed in claim 1,

c h a r a c t e r i z e d in that the hierarchical graphic
representation comprises, as a basis, a geographical map
in different scales, and the number of calls in a specific
area is shown with grades of colour so that as the number
of calls in the area increases the colour intensifies.

5. A management system as claimed in claim 1 or 3,
c h a r a c t e r i z e d in that the user may select on
the display any level of the group of levels, comprising
the entire network, MSC areas, location areas and cells.

6. A management system as claimed in claim 2,
c h a r a c t e r i z e d in that the means for giving
commands concerning the cell capacity comprise

congestion calculation means that calculate, for
each cell, the ratio of failed channel requests to all
channel requests,

comparison means for comparing said ratio to a
preset threshold value,

means for giving the command as the ratio exceeds
the threshold value.

7. A management system as claimed in claims 2 or 6,
c h a r a c t e r i z e d in that the command includes a
request to increase the cell capacity by changing handover
criteria.

8. A management system as claimed in claims 2 or 6,
c h a r a c t e r i z e d in that the command includes a
request to add an additional transceiver unit TRX for use
in the cell.

9. A management system as claimed in claims 1 or
6, c h a r a c t e r i z e d in that it utilizes
information obtained from the TT file for calculating
various kinds of statistics.

10. A method for managing call traffic in a mobile
communication network comprising one or more mobile
services switching centers MSC, base stations and their
controllers which communicate with the MSCs, mobile

subscribers communicating with the base stations for transmitting and receiving information, the method comprising the steps of

5   generating, at predetermined intervals, from the MSCs for the operator, a TT file which comprises at least fields that contain at least a number A, number B, route information, charging data, such as begin and end time and pulses of the call, cell ID and a congested calls data,

transferring predetermined fields to the traffic
10 management system for further processing,

summing the cell ID fields of each cell in a database to represent the number of calls in the cell in question during a specific time interval,

displaying the number of calls as a hierarchical
15 representation in which the highest level depicts the operator's entire mobile communication network, and the lowest level depicts a cell.

11.   A method as claimed in claim 10, c h a r a c t e r i z e d further by giving a command
20 concerning the capacity of the cell automatically to the MSC when the load in any cell exceeds a preset value.

12.   A method as claimed in claim 10, c h a r a c t e r i z e d in that traffic intensity is represented on a display unit in a graphic form so that a
25 map display shows the operator's entire area of operation.

13.   A method as claimed in claim 10, c h a r a c t e r i z e d by displaying a hierarchical representation of traffic intensity in a cell, location area or MSC area, or several MSC areas.
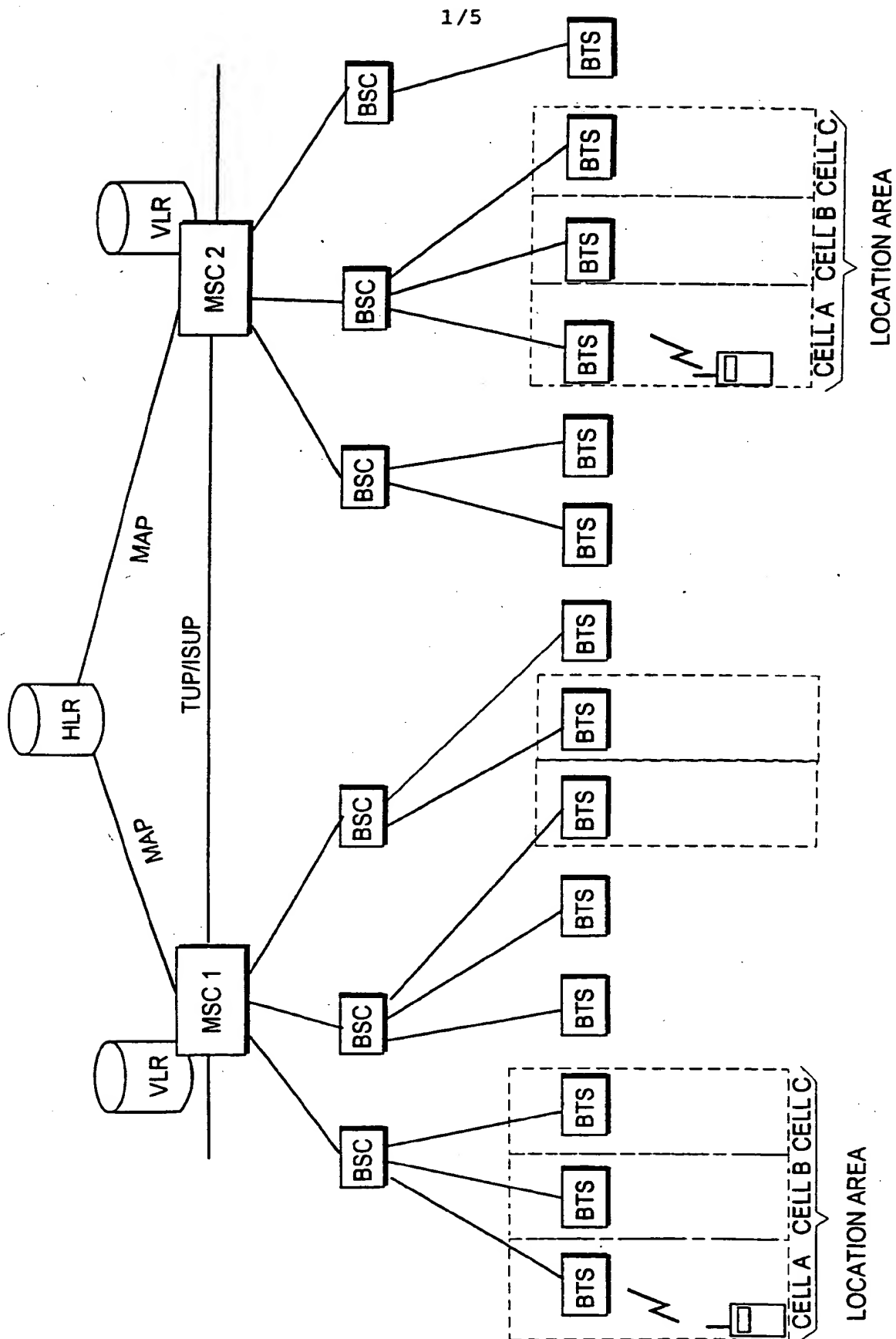
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Fig.1

NUMBER A	NUMBER B	DATE	BEGIN TIME	END TIME	ROUTE	CELL ID	PULSES	EOS
111	888	5.6.1995	8:00	8:06	1	50	5	0
115	887	5.6.1995	8:12	8:18	2	52	12	0
114	886	5.6.1995	8:15		5	57	0	10
113	889	5.6.1995	8:07	8:21	1	50	12	0

Fig.2
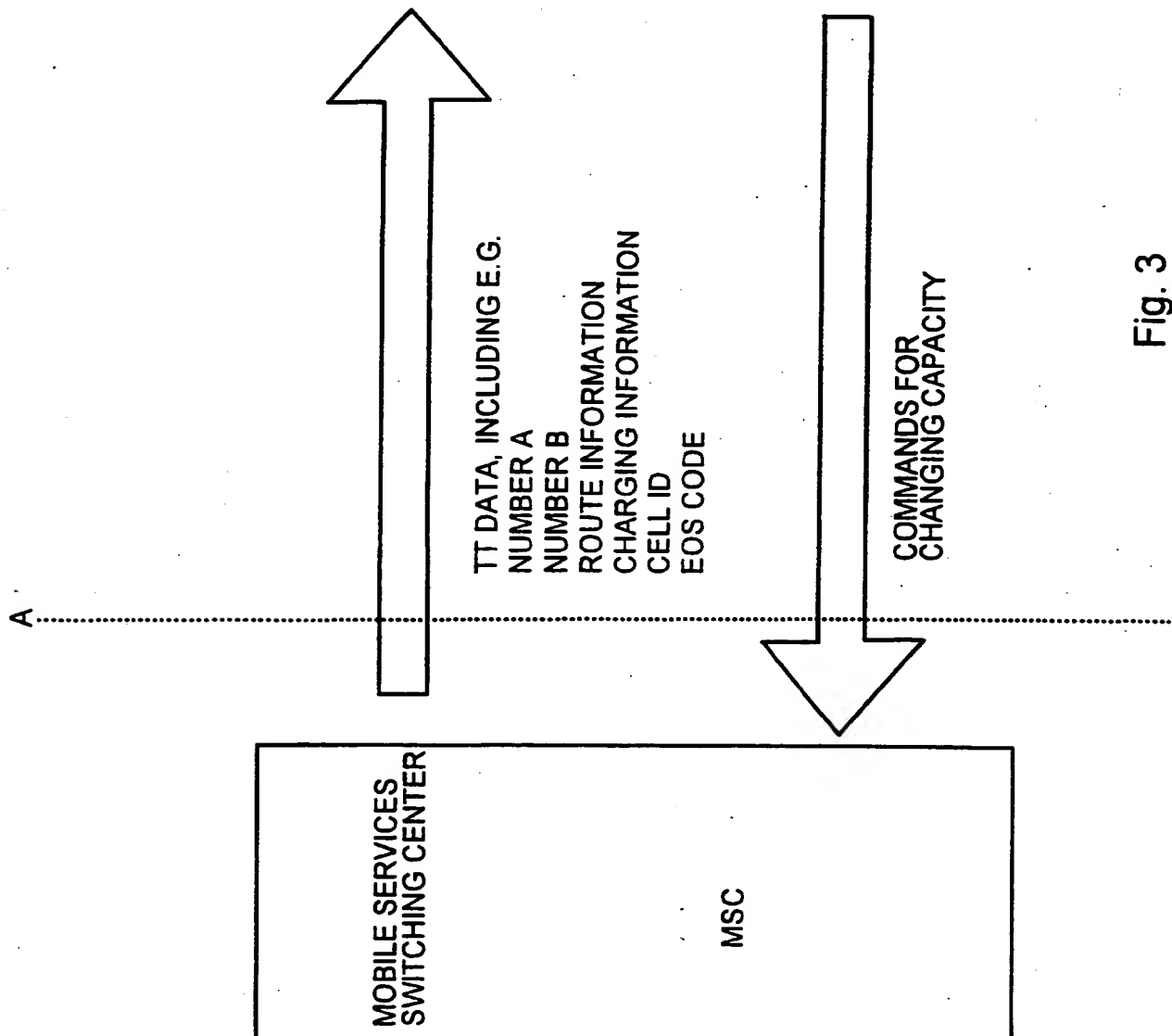
TRAFFIC
MANAGING
SYSTEM

COMMAND
AUTOMATICS

DISPLAY
GRAPHICS

TT DATA, INCLUDING E.G.
NUMBER A
NUMBER B
ROUTE INFORMATION
CHARGING INFORMATION
CELL ID
EOS CODE

COMMANDS FOR
CHANGING CAPACITY

A

MOBILE SERVICES
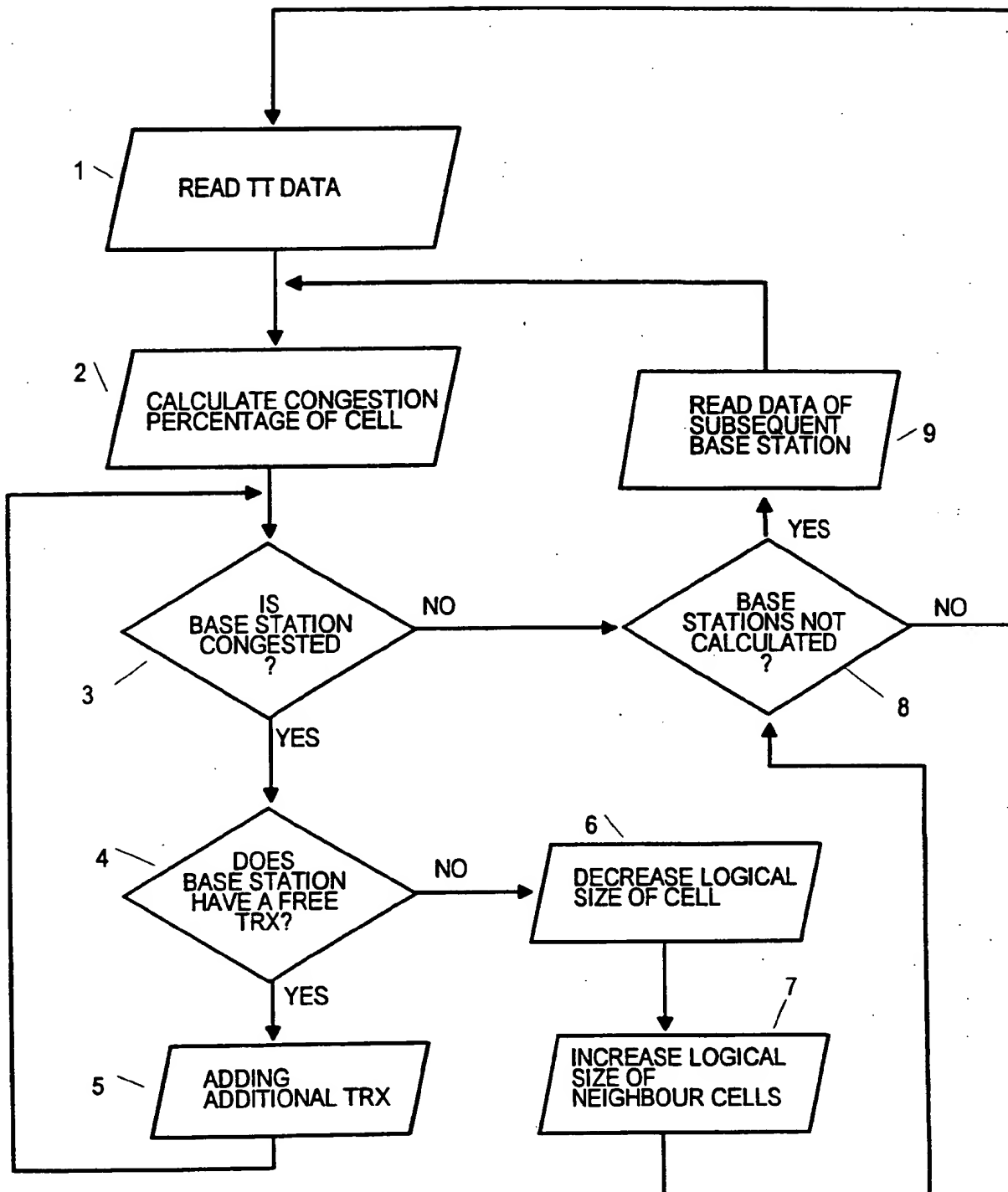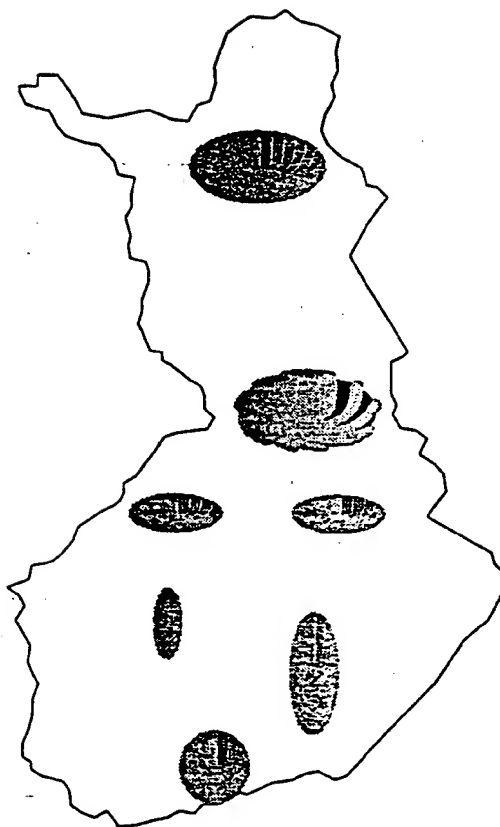SWITCHING CENTER

MSC

Fig. 3

Fig. 4

Fig. 5

INTERNATIONAL SEARCH REPORT

International application No.

PCT/FI 96/00384

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: H04Q 7/34, H04Q 7/36, H04Q 7/38 // T04Q 7/38T

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: H04Q, H04M

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5285494 A (JERRY W. SPRECHER ET AL), 8 February 1994 (08.02.94), column 1, line 53 - line 54; column 1, line 62 - line 64; column 3, line 11 - line 17, figures 4-4C, column 6, rad 45 - 56, column 7 rad 43 - 59	1-13
A	WO 9400959 A1 (NOKIA TELECOMMUNICATIONS OY), 6 January 1994 (06.01.94), page 4, line 20 - line 26; page 5, line 23 - line 30; page 8, line 32 - page 9, line 3	1-13
A	EP 0505341 A2 (TELEFONAKTIEBOLAGET LM ERICSSON), 23 Sept 1992 (23.09.92), abstract	7

[X] Further documents are listed in the continuation of Box C.　　[X] See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
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"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
5 November 1996	06 -11- 1996

Name and mailing address of the ISA/	Authorized officer
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INTERNATIONAL SEARCH REPORT

International application No.

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C (Continuation).   DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
P,A	EP 0701382 A1 (AT & T CORP.), 13 March 1996 (13.03.96), column 2, line 33 - line 37 --	1-13
P,A	US 5517555 A (CHARLES G. AMADON ET AL), 14 May 1996 (14.05.96), abstract --	1-13
P,A	EP 0708573 A2 (TELIA AB), 24 April 1996 (24.04.96), see whole document -- ----------	1-13

Form PCT/ISA/210 (continuation of second sheet) (July 1992)

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			AU-A-	4502593	24/01/94
			EP-A-	0648402	19/04/95
			FI-B,C-	96565	29/03/96
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			US-A-	5241685	31/08/93
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			WO-A-	9312606	24/06/93
EP-A2-	0708573	24/04/96	NONE		

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